Kodiak Launch Complex, Alaska
2002 Environmental Monitoring Studies
April QRLV-2 Launch

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Contents

Tables and Figures

Tables

Figures

Introduction

This document provides the results of environmental monitoring studies done in support of the 24 April 2002 launch of the second U.S. Air Force (USAF) Quick Reaction Launch Vehicle (QRLV-2) from the Kodiak Launch Complex (KLC). The rocket was the sixth to be launched from KLC and was a single stage M-56 motor taken from a decommissioned USAF Minute II launch vehicle. KLC is located on the Narrow Cape peninsula of Kodiak Island, Alaska, and is owned and operated by the Alaska Aerospace Development Corporation (AADC). The University of Alaska Anchorage's Environment and Natural Resources Institute (ENRI) conducted the QRLV-2 environmental studies under contract to AADC, which is a state-owned entity. ENRI also conducted the environmental baseline studies (ENRI 1995–98) for the initial National Environmental Policy Act process for KLC, as well as the 1998–2001 monitoring studies (ENRI 1999, 2000, 2001, 2002a,b) for the first five missions as required by the KLC Environmental Monitoring Plan (EMP) (AADC 1998).

The EMP was developed by ENRI in cooperation with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Alaska Department of Environmental Conservation (ADEC). It includes work plans, sampling protocols, objectives, and criteria that trigger mandatory agency consultation for five environmental monitoring tasks: Steller sea lion surveys, rocket motor noise measurements, bald eagle nest monitoring, Steller's eider surveys, and environmental quality monitoring. The EMP had a design life of five launches provided at least one was of the largest rocket that could be flown from KLC. That requirement was met in September 2001 with the launch of a Lockheed/Martin Athena, and the fifth launch occurred in November of that year. In March 2002, AADC requested that ENRI invite the resource agencies involved in developing the EMP to meet and review the findings of the 1998–2001 environmental studies and help determine future courses of action. NMFS, ADEC, and the Alaska Division of Governmental Coordination attended the 12 March 2002 meeting; all expressed an interest in continuing with the overarching intent of the EMP.

AADC subsequently requested that ENRI develop an integrated series of environmental monitoring studies for KLC launches in 2002 and specifically the QRLV-2, which was the first mission scheduled that would not fall under the EMP. Given the late April to early May QRLV-2 launch window, ENRI recommended that studies relating to the Steller's eider and environmental quality be conducted. ENRI patterned the QRLV-2 studies on the EMP, the findings and recommendations of the first five KLC environmental monitoring (ENRI 1999, 2000, 2001, 2002a,b) and summary findings (ENRI 2002c) reports, and resource agency input from the March 2002 meeting. ENRI focused on the same primary study area as defined in the EMP; it encompasses the lands and waters within a circular area having a 6-mile radius extending out from the KLC launch pad (Figure 1). Descriptions of the QRLV-2 environmental monitoring studies and results follow.

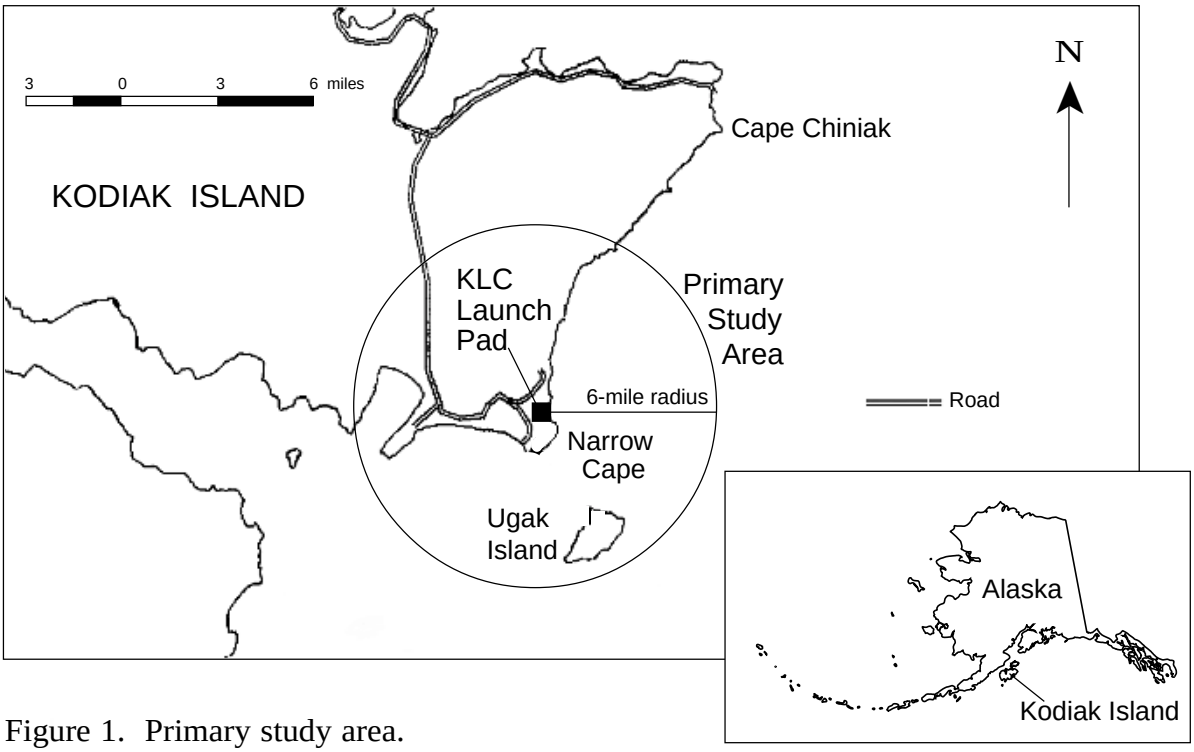


Figure 1. Primary study area.

Steller's Eider Surveys

Objectives

The principal objectives of the Steller's eider *(Polysticta stelleri)* surveys are to document whether rocket motor noise causes 50% or more of the eiders in the primary study area to leave immediately after a launch; and if so, to determine if numbers reestablish to prelaunch levels within five days. USFWS and ENRI set the 50% benchmark during the EMP review process to account for the fact that the numbers of Steller's eiders in the study area are known to fluctuate greatly over short time frames from a few dozen to a thousand or more. If the 50% benchmark is reached, AADC is to consult with USFWS. The Steller's eider is only present near KLC during the winter months (generally mid-October through March); therefore, USFWS designated the harlequin duck *(Histrionicus histrionicus)* as its surrogate for monitoring purposes at other times.

Methods

The harlequin duck was the focus of the monitoring studies for the QRLV-2 launch, which was scheduled in late April when the Steller's eider was not expected to be in the study area. ENRI conducted point-count surveys at 11 locations (Figure 2, stations 5–13) and did a complete survey of the lagoon immediately northeast of the launch pad (Figure 2, South Lagoon).

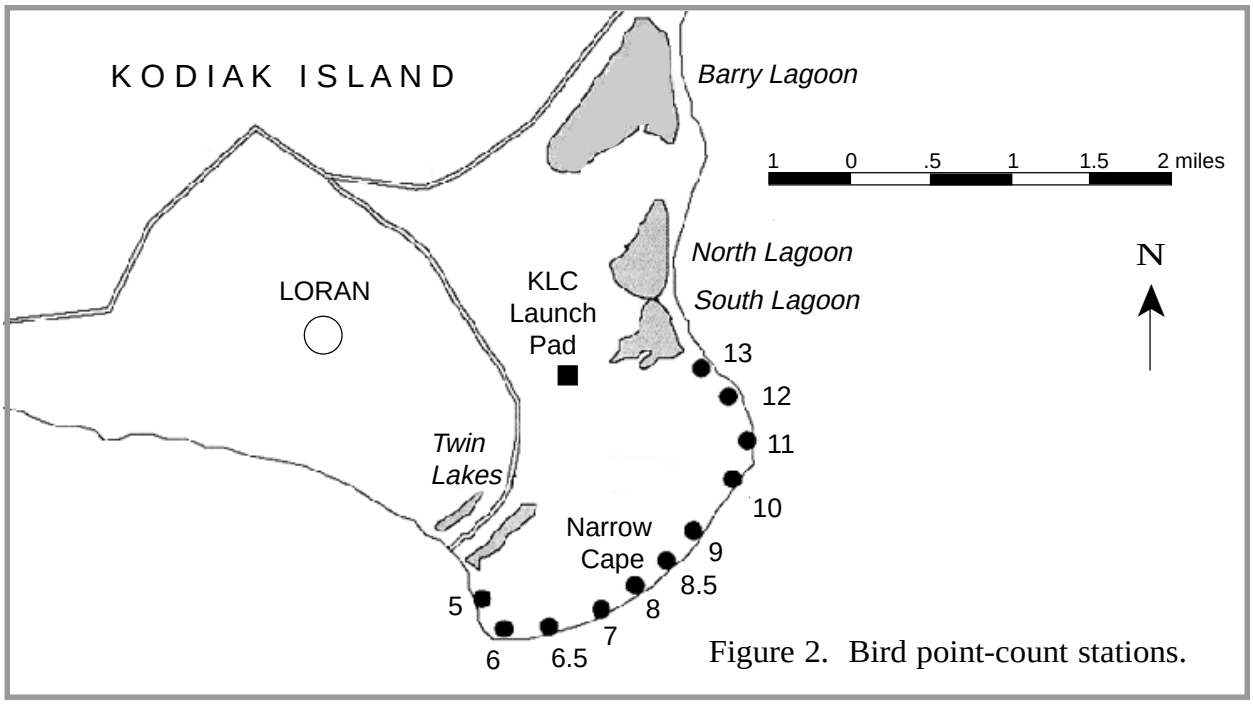


Figure 2. Bird point-count stations.

During a point-count survey, all birds seen within a 500-meter radius of each point-count station over a 15-minute period are identified to species and tallied. A primary observer is responsible for identifying all birds seen and calling out the numbers of each species to a secondary observer, who in addition to maintaining the record, tracks the movement of birds into and out of the point-count area. When conditions permit, surveys are scheduled so that the midpoint of each occurs during high tide.

Results

Four prelaunch and three postlaunch bird surveys were successfully conducted 20–26 April. The date, time, and weather conditions for each survey are provided in Appendix A. The weather was generally conducive to locating, counting, and identifying birds, but strong winds on 21 and 24 April made conditions somewhat difficult. Although not normally present at this time of year, Steller's eiders were observed during the first survey.

The numbers of harlequin duck remained relatively constant throughout the surveys (Figure 3). The average numbers observed were 59 prelaunch and 60 postlaunch (Table 1). A total of 32 bird taxa were sighted during the seven point-count surveys (Table 1). This is the greatest number of bird species seen during any monitoring study done in conjunction with a KLC rocket launch. Ten of these species were observed only once during the study period, which coincided with

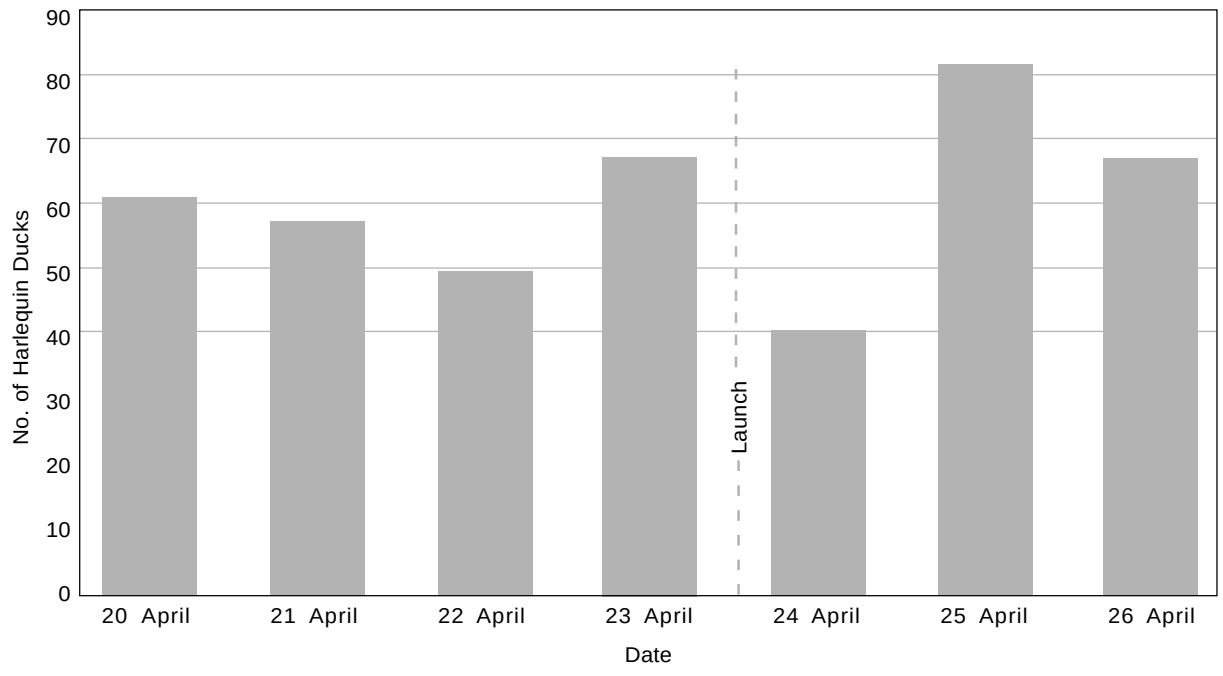


Figure 3. Harlequin duck point-count numbers.

Table 1. Point-count bird survey data.

Species	Prelaunch						Postlaunch				
	20 April	21 April	22 April	23 April	Total	Average	24 April	25 April	26 April	Total	Average
Bald Eagle	9	2	3	4	18	5	4	4	2	10	3
Black Oystercatcher	23	1		2	26	7	6	2	20	28	9
Black Scoter	10	18	50	11	89	22	52	180	68	300	100
Brant		12			12	3		1145	45	1190	397
Bufflehead					0	0		2	12	14	5
Common Loon				1	1	0				0	0
Common Merganser	19	5	3	6	33	8		9	3	12	4
Common Murre			15	3	18	5				0	0
Common Raven	4	2	2		8	2	4	2	1	7	2
Double-Crested Cormorant	1	1	1	5	8	2	1			1	0
Glaucous-Winged Gull	5	52	63	4	124	31	17	3		20	7
Godwit					0	0			1	1	0
Golden Eagle			1		1	0		2		2	1
Golden Plover		1	4	3	8	2				0	0
Harlequin Duck	61	59	50	67	237	59	40	82	57	179	60
Herring Gull	1				1	0				0	0
Kittlitz's Murrelet				2	2	1		2		2	1
Lesser Yellowlegs					0	0			1	1	0
Mallard Duck				8	8	2	2	3	14	19	6
Marbled Murrelet				1	1	0				0	0
Mew Gull					0	0	1			1	0
Northwestern Crow	3			30	33	8		32	30	62	21
Pacific Loon	4	2		6	12	3	2	12	5	19	6
Pelagic Cormorant	11	7	1		19	5	4	7	32	43	14
Pigeon Guillemot				31	31	8	1	3	17	21	7
Pintail				30	30	8				0	0
Red-Necked Grebe				4	4	1		1	2	3	1
Red-Tailed Hawk			1		1	0				0	0
Scaup				3	3	1				0	0
Steller's Eider	75				75	19				0	0
Surf Scoter				10	10	3	6			6	2
White-Winged Scoter	12	40	40	29	121	30	25	8	57	90	30
Total	238	202	234	260	934	234	165	1499	367	2031	677

spring migration. Brant *(Branta bernicla)* was by far the most numerous species; a flock of over a thousand migrated through the area on 25 April. Excluding brant, the most common taxon in terms of numbers was harlequin duck, followed by black scoter *(Melanitta nigra),* and white-winged scoter *(Melanitta fusca)* (Table 1). Bird data are listed by point-count station in Appendix B.

The number of bird taxa observed per survey ranged from 13 to 21 prelaunch and from 14 to 18 postlaunch (Table 1). Bird counts were variable, ranging from 202 to 260 prelaunch and

from 165 to 1499 postlaunch (Table 1). The large variability in the postlaunch numbers was due to the migrating flock of brant. When the brant were excluded from the Student's t-test, no statistically significant difference was detected between the pre- and postlaunch taxa richness or bird abundance.

A breeding pair of bald eagles was observed on the nest near point-count station 6 (Figure 2) during all seven surveys.

Discussion

Steller's eiders were only observed in the study area during the first survey, therefore no conclusions regarding the effects of rocket motor noise on this species can be drawn. Pre- and postlaunch harlequin duck numbers were similar, indicating the QRLV-2 launch did not adversely affect the species. The rocket launch also did not produce noticeable effects on the bald eagles that were nesting near point-count station 6.

Bird abundance and taxa richness showed considerable variation from survey to survey. Weather variables, especially wind, appear to be responsible for some of this variation, but much of it is likely attributable to the timing of the surveys, which coincided with spring migration. The data from this and other bird studies done for the previous five KLC launches (ENRI 1999, 2000, 2001, 2002a,b) strongly suggest that rocket operations are not having a measurable effect on bird habitat use patterns in the primary study area.

Environmental Quality Monitoring

Objectives

The objective of the environmental quality monitoring studies at KLC is to detect any adverse effects to soil, water, and vegetation attributable to rocket flight operations. Solid rocket motors on firing release large quantities of exhaust products that consist chiefly of hydrogen chloride, carbon monoxide, nitrogen oxides, and aluminum oxide.

Methods

ENRI used three complementary procedures to monitor environmental quality for the QRLV-2 launch. These included taking surface water chemistry data to detect any changes in aquatic chemistry, collecting aquatic macroinvertebrates as biological indicators of change, and surveying epiphytic macrolichens to monitor vegetation. The methods used for each of these procedures are described below.

Water Chemistry

Water pH, dissolved oxygen, temperature, and conductivity were measured in situ following the QRLV-2 launch at streams 2, 7, and 8 (Figure 4) using a Hydrolab MiniSonde multiprobe and Surveyor 4 data display unit. Dissolved oxygen is reported as milligrams per liter (mg/L), temperature as degrees Celsius (ºC), and conductivity as microSiemens per centimeter (µS/cm).

Water samples for the alkalinity analyses were collected postlaunch at streams 2, 7, and 8 (Figure 4) in clean 300-milliliter (ml) nalgene bottles and preserved by freezing until analysis. Alkalinity is typically expressed as milligrams calcium carbonate per liter (mg $CaCO_3$/L). The alkalinity water samples were taken to Northern Testing Laboratories in Anchorage for analyses.

ENRI also collected water samples for total aluminum and perchlorate analyses. Samples for the aluminum analyses were collected postlaunch from streams 2, 4, 7, and 8 (Figure 4) in clean 300 ml nalgene bottles, each containing 5 ml nitric acid (2 molar concentration). Samples for the perchlorate analyses were collected postlaunch from streams 2, 4, 7, and 8 in clean 300 ml nalgene bottles and refrigerated until analysis at ENRI's Applied Sciences, Engineering, and Technology (ASET) lab.

Metals analyses were conducted by inductively coupled plasma mass spectroscopy (ICP-MS) in the ASET lab. Three replicates were analyzed from each sample. Precision of the ICP-MS was dependent upon the concentration of each element. Matrix detection limits (MDL) and the limit of detection (LOD) of the instrument were determined using internationally accepted quality control methods, where the calibration curves for each element were regressed to pro-

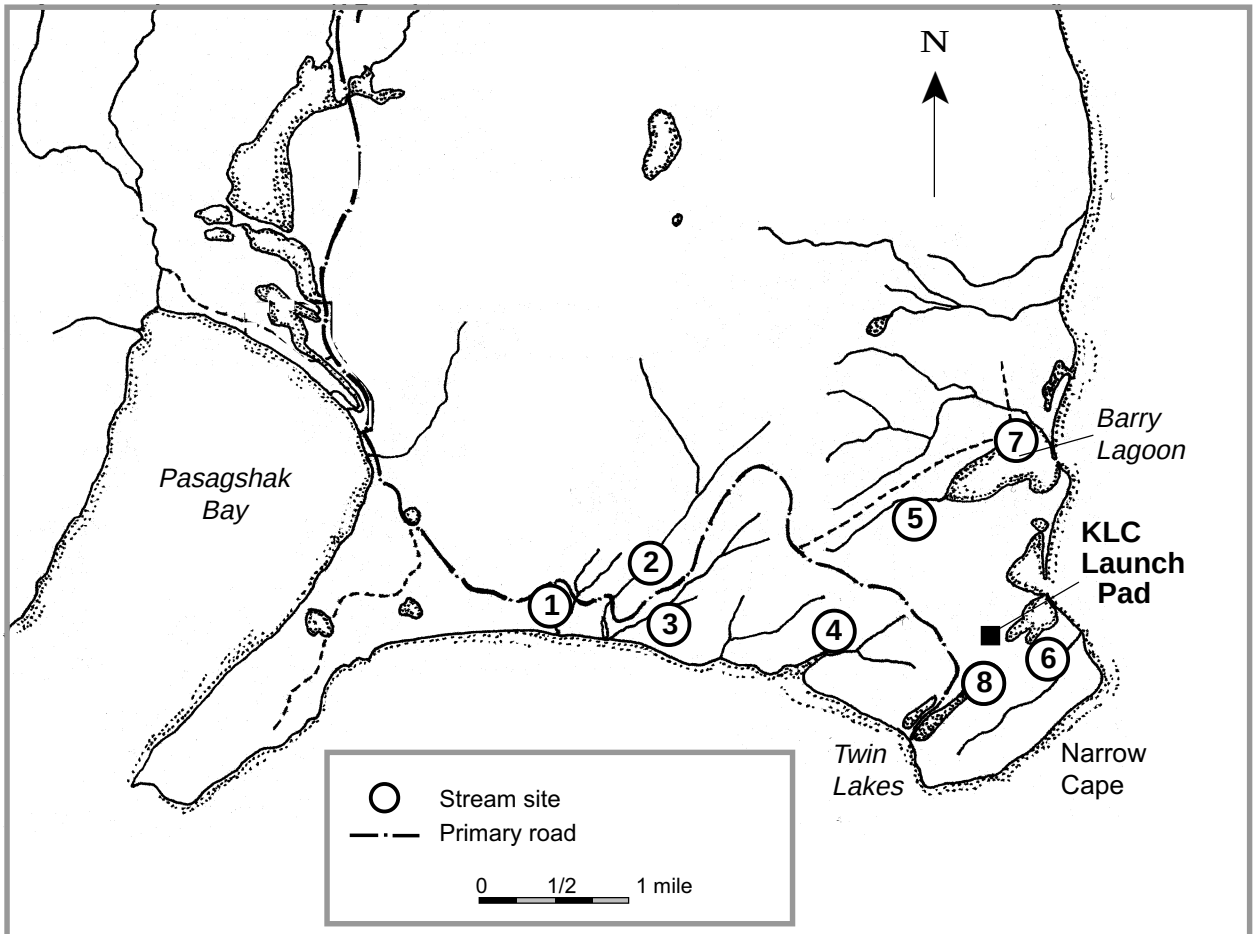


Figure 4. Water quality study sites.

duce the standard error. The LOD for total aluminum was 0.9 micrograms per liter (µg/L) and the MDL was 2.9 µg/L. Perchlorate was analyzed by ion chromatography with detection limits determined as outlined in U.S. Environmental Protection Agency Method 314.0. The overall average MDL for perchlorate was determined to be 0.85 µg/L; the minimum reporting level (MRL) was 2.6 µg/L.

Macroinvertebrates

ENRI collected aquatic macroinvertebrates after the QRLV-2 launch from stream 2 (Figure 4), which was also sampled for the 1994 KLC baseline survey and in conjunction with the studies for the first five launches. ENRI has used the standardized sampling and analysis methods outlined in the Alaska Stream Condition Index (ASCI) (Major and Barbour 1997, 2001) for all KLC studies since 1998. Data quality procedures—such as sampling precision, bias, and sensitivity—have been documented for ASCI to define the level of accuracy (Barbour et al. 1999).

A composite sample of 20 sweeps or jabs was collected from the predominant habitats over a 100-meter reach using a D-frame dip net. Habitats were sampled in proportion to their representation within the selected stream reach. Samples were returned to ENRI's wet lab for processing, where they were subsampled to 300 organisms (± 20%) using a Caton subsampler (Caton 1991). The organisms were identified to genus when possible.

ENRI has used the same measures (metrics) for all of its KLC macroinvertebrate studies. These include total number of taxa—a community diversity measure; number of Ephemeroptera, Trichoptera, and Plecoptera (EPT)—a pollution intolerance measure; and percent dominant taxa and family level biotic index (FBI)—pollution tolerance measures. Total number of taxa and number of EPT taxa are expected to increase with improved water quality, while percent dominant taxon and FBI value are expected to decrease with improved water quality (Hilsenhoff 1988). This approach detects water quality impairment and is used by many states with established water quality monitoring programs. The approach in Alaska has been developed and tested with ADEC support to evaluate clear water, wadeable streams on a regional basis.

Vegetation

Epiphytic macrolichens were first measured and sampled at six sites near the KLC launch facility (Figure 5) in 1998 prior to the first launch. Lichen cover was measured on 20 spruce branches in each plot following the methods in McCune (1990) and Geiser, Derr, and Dillman (1994). Selected branches were photographed with reference markers to help determine gross changes in lichen cover or morphology following launches. Additional photographs were taken of the growing tips of spruce branches in each plot as an aid in detecting unusual needle loss. Lichen cover was resampled in late June 1999 and again in early June 2002 following the QRLV-2 launch using the same methods as in 1998 (ENRI 1999). New photographs were taken of all photo plots.

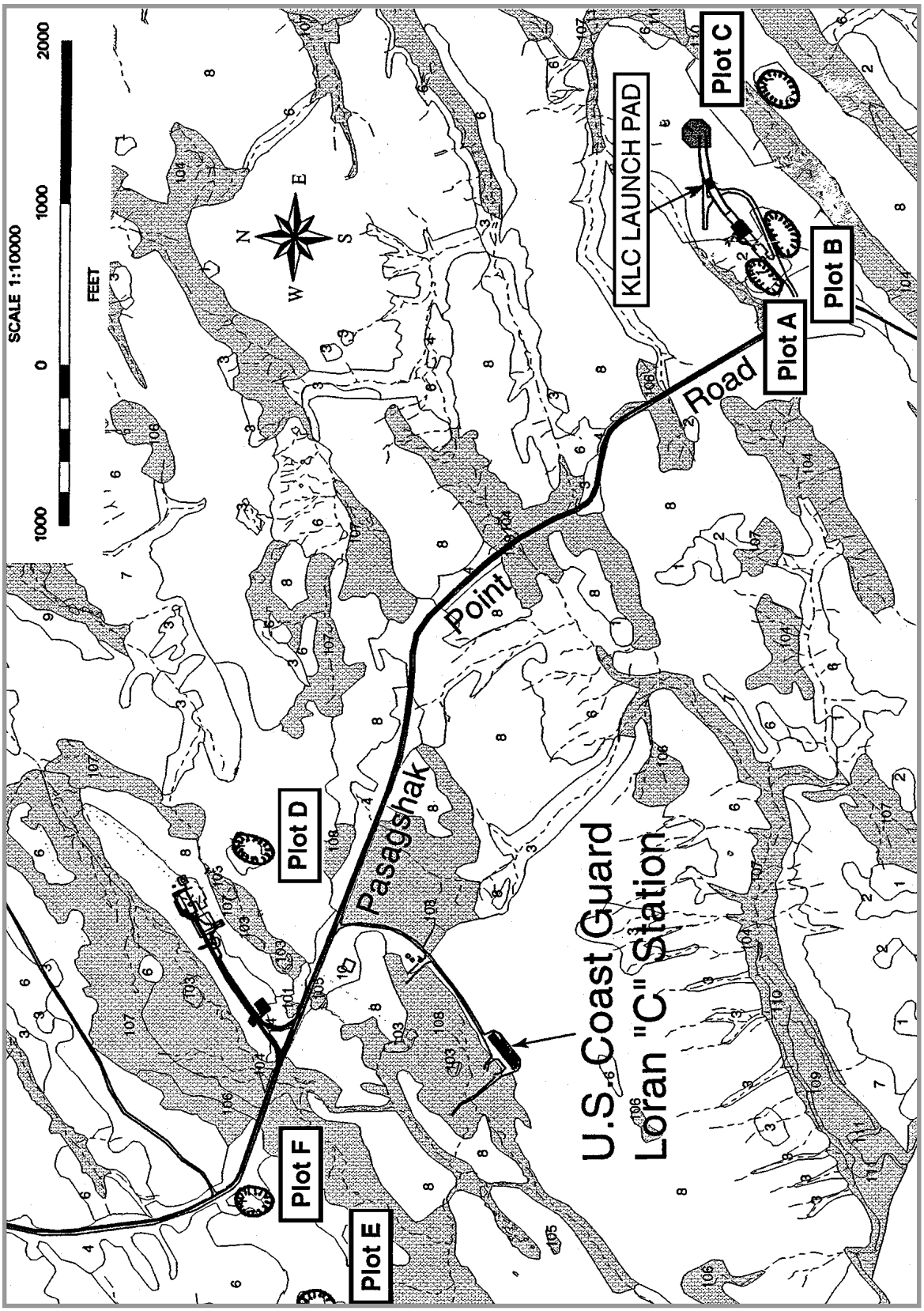
Results

Water Chemistry

In situ water chemistry (pH, dissolved oxygen, temperature, and conductivity) values were all normal for the time of year and showed no effects from KLC launches (Table 2). Alkalinity measures were below 20 mg $CaCO_3$/L for the water bodies tested, indicating a low buffering

Table 2. Water chemistry results, 16 May 2002.

Location	*Temperature (°C)*	*Dissolved Oxygen (mg/L)*	*pH*	*Conductivity (µS/cm)*	*Alkalinity ($mgCaCO_3$/L)*
Stream 2	8.2	11.7	7.5	58.9	11
Stream 7	10.3	10.1	7.2	70.7	10
Stream 8	12.6	9.4	7.2	146.6	14



(From *Map of Major Vegetation Types in the Vicinity of Ugak Bay, Kodiak Island, Alaska* (ENRI 1995–98).

Figure 5. Macrolichen study plots.

capacity in these waters. All water chemistry measurements were consistent with recorded values for the area, as well as those from previous analyses (ENRI 1999, 2000, 2001, 2002a,b).

Total recoverable aluminum was determined for the four water bodies sampled and ranged from 19.5 µg/L at stream 8 to 139.8 µg/L at stream 4 (Table 3). The values reported are the averages of the three replicates for each site. Perchlorate was not detected at any site (Table 3).

Table 3. Total aluminum and perchlorate concentration, 24 April 2002. (ND = not detected.)

Location	*Total Aluminum (µg/L)*	*Perchlorate (µg/L)*
Stream 2	38.1	ND
Stream 4	139.8	ND
Stream 7	40.0	ND
Stream 8	19.5	ND

Macroinvertebrates

Macroinvertebrate metrics are reported in Table 4 and indicate good water quality at stream 2. In May 2002 there were 19 taxa reported, 10 of which were of the EPT orders. The dominant taxa made up only 24% of the total numbers of individuals, and the FBI was 4.4. Appendix C provides a complete macroinvertebrate taxa list for stream 2.

Table 4. Macroinvertebrate metrics.

Location	*Date*	*Total Taxa*	*EPT Taxa*	*Dominant Taxon %*	*FBI*
Stream 2	Oct 98 baseline	18	10	32	3.0
	Nov 98	20	13	17	2.5
	Oct 99	18	10	31	2.4
	Mar 01	20	12	26	3.1
	Sep 01	14	9	43	1.4
	Nov 01	21	13	29	2.0
	May 02	19	10	24	4.4

Vegetation

No obvious changes in lichen cover or morphology were found when the 1999 and 2002 photographs were compared with the 1998 baseline photographs. Although some browning and loss of needles on spruce trees was apparent in the 1999 photographs, this was minor and seen

on both the test and control plots. No obvious additional needle loss or browning was seen in the 2002 photographs. Construction of a new fence and gate at Plots A and B (Figure 5) caused some disturbance to both of these test plots, including loss of two trees and several branches (these branches were excluded from the analyses). Using a paired t-test, mean cover of lichens showed no significant changes on the test plots (Table 5).

Table 5. Mean percent cover of epiphytic lichens.

		Percent Cover	
Plot		*1998 Baseline*	*2002*
Test	A	57.6	60.3
	B	43.1	42.1
	C	84.6	80.3
Control	D	42.3	38.5
	E	53.0	56.2
	F	58.8	58.0

Discussion

Water Chemistry

All measured water chemistry parameters (pH, dissolved oxygen, temperature, and conductivity) remained normal, which continues to indicate no effects to environmental quality from KLC launches.

Total recoverable aluminum was detected in low concentrations in the four water bodies sampled; none of these levels exceeded those considered to be toxic to aquatic life (ENRI 2002a). The values found are comparable to those from previous sampling at these sites as well as to those found elsewhere in Alaska (ENRI 2002a). Importantly, there was no associated decrease in pH to warrant concern from aluminum toxicity. Perchlorate was not detected in any water body tested near KLC. This was expected, as perchlorate would only be present if a rocket launch failed over land.

Macroinvertebrates

The macroinvertebrate community of stream 2 indicated no degradation in water quality due to the QRLV-2 rocket launch. Total taxa, EPT, and percent dominant taxon were all within the ranges of expected values that have been documented since 1998 (ENRI 2002c). The FBI index (an indicator of organic pollution) was slightly elevated from previous results but not significantly so. This slightly elevated index is likely due to the high numbers of tolerant Chironomidae (midges) and Baetidae (mayflies) that dominated the sample. This change is likely due to seasonal differences and not to environmental degradation.

Vegetation

The photo plots were designed to detect acute effects on vegetation from both the ground cloud caused by rocket motor exhaust and from the direct deposition of exhaust products generated during launch. No significant changes were seen in lichen cover or spruce needle cover from the photo plots or in the measurements of lichen cover on branches.

References Cited

Alaska Aerospace Development Corporation. 1998. *Natural Resources Management Plan for the Kodiak Launch Complex, Narrow Cape, Kodiak Island, Alaska*. Anchorage, AK.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish.* 2nd ed. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA 841-B-99-002.

Caton, L.W. 1991. Improving subsampling methods for the EPA "Rapid Bioassessment" benthic protocols. *Bulletin of the North American Benthological Society.* 8(3):317–319.

Geiser, L.H., C.C. Derr, and K.L. Dillman. 1994. *Air quality monitoring on the Tongass National Forest: methods and baselines using lichens.* U.S. Forest Service Alaska Region R10–TB-46.

Hilsenhoff, W.L. 1988. Rapid field assessment of organic pollution with a family-level biotic index. *Journal of the North American Benthological Society.* 7(1):65–68.

Major, E.B., and M.T. Barbour. 2001. *Standard operating procedures for the Alaska Stream Condition Index: a modification of the U.S. EPA Rapid Bioassessment Protocols.* 5th ed. Environment and Natural Resources Institute, University of Alaska Anchorage, Anchorage, AK. Prepared for the Alaska Dept. of Environmental Conservation. 1 vol.

———. 1997. *Standard operating procedures for the Alaska Stream Condition Index: a modification of the U.S. EPA Rapid Bioassessment Protocols.* Environment and Natural Resources Institute, University of Alaska Anchorage, Anchorage, AK. Report for the Alaska Dept. of Environmental Conservation. 1 vol.

McCune, B. 1990. Rapid estimation of abundance of epiphytes on branches. *The Bryologist* 93(1):39–43.

University of Alaska Anchorage, Environment and Natural Resources Institute. 2002a. *Kodiak Launch Complex, Alaska, environmental monitoring studies, November 2001 STARS launch.* Final report. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 1 vol.

_____. 2002b. *Kodiak Launch Complex, Alaska, environmental monitoring studies, September 2001 Athena launch.* Final report. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 1 vol.

_____. 2002c. *Summary findings of environmental monitoring studies for the Kodiak Launch Complex 1998–2001*. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 27 pp.

_____. 2001. *Kodiak Launch Complex, Alaska, environmental monitoring studies, March 2001 QRLV launch.* Final report. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 1 vol.

_____. 2000. *Kodiak Launch Complex, Alaska, environmental monitoring studies, September 1999* ait-*2 launch.* Final report. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 1 vol.

_____. 1999. *Kodiak Launch Complex, Alaska, environmental monitoring studies, November 1998* ait-*1 launch.* Vol. 1. Final report. Vol. 2. Appendices. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 2 vols.

_____. 1995–98. *Environmental baseline of Narrow Cape, Kodiak Island, Alaska.* Vol. 1. Final report. Vol. 2. Appendices 1–3. Vol. 3. Appendices 4–8. Vol. 4. Supplemental surveys of pinnipeds, marine birds, and sea ducks. Anchorage, AK. Report for Alaska Aerospace Development Corporation. 4 vols.

Appendix A

QRLV-2 Bird Survey Weather Data

Table 1. Bird survey weather data, 20–26 April 2002.

Date	Survey Time Start	Stop	% Cloud Cover	Visibility (mi)	Wind Direction	(mph)	Precipitation	Glare	Wave Height (ft)	Comments
20 April	15:35	18:50	20	7	SE	10–25	none	5	2	
21 April	11:05	13:40	0	unlimited	SE	30–50	none	7	0–5	High winds, blowing sand
22 April	11:05	14:50	0	unlimited	SE	5–15	none	6	0–3	
23 April	10:45	14:00	95	7	E	0–10	none	5	1–5	
24 April	14:55	17:30	70	7	NE	10–40	none	4	3–5	Strong winds, low front passing through
25 April	10:20	13:25	100	6	E	0–3	none	4	4–5	
26 April	10:15	13:15	20	7	SW	0–10	none	6	2–3	

Appendix B

QRLV-2 Bird Survey Data

Table 1. Bird survey data by point-count station, 20 April 2002.

Species	*Point-Count Station*												
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	*Total*
Bald Eagle		2					2	1	3	1			9
Black Oystercatcher	6			2				15					23
Black Scoter				1		2	3				4		10
Common Merganser									4		15		19
Common Raven			3	1									4
Double-Crested Cormorant				1									1
Glaucous-Winged Gull		1		1			1	2					5
Harlequin Duck		2	8	10	24	3	2	4			8		61
Herring Gull					1								1
Northwest Crow								3					3
Pacific Loon						2	2						4
Pelagic Cormorant		2			3	1	1		1		3		11
Steller's Eider						15				45	15		75
White-Winged Scoter							9			3			12
Total Birds													238
Harbor Seal			1						12				
Sea Otter								1					
Gray Whale	10				1								

Table 2. Bird survey data by point-count station, 21 April 2002.

Species	*Point-Count Station*												*Total*
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	
Bald Eagle		1			1								2
Black Oystercatcher							1						1
Black Scoter					9	9							18
Brant											12		12
Common Merganser											5		5
Common Raven				2									2
Double-Crested Cormorant							1						1
Glaucous-Winged Gull		3		6	30	3	10						52
Golden Plover					1								1
Harlequin Duck	6	4	8	7	3	4	8	5			14		59
Pacific Loon											2		2
Pelagic Cormorant			2	4	1								7
White-Winged Scoter											40		40
Total Birds													202
Harbor Seal					1	1			50	2			

Table 3. Bird survey data by point-count station, 22 April 2002.

Species	*Point-Count Station*												*Total*
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	
Bald Eagle		1		1						1			3
Black Scoter			4	11			35						50
Common Merganser												3	3
Common Murre			5	10									15
Common Raven		1		1									2
Double-Crested Cormorant						1							1
Glaucous-Winged Gull		6		2	2	3		24	18	8			63
Golden Eagle			1										1
Golden Plover		4											4
Harlequin Duck	5	2	6	3	15	5	3	5			6		50
Pelagic Cormorant							1						1
Red-Tailed Hawk							1						1
White-Winged Scoter		2	5	3							30		40
Total Birds													234
Harbor Seal	1		1			2			20				
Gray Whale	3	3											

Table 4. Bird survey data by point-count station, 23 April 2002.

Species	*Point-Count Station*												
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	*Total*
Bald Eagle		1					3						4
Black Oystercatcher	2												2
Black Scoter	3			2		1		2			3		11
Common Loon	1												1
Common Merganser											4	2	6
Common Murre				2							1		3
Double-Crested Cormorant				1		4							5
Glaucous-Winged Gull								4					4
Golden Plover					3								3
Harlequin Duck	3	5	2	11	9	14	10	2	1	7	3		67
Kittlitz's Murrelet											2		2
Mallard												8	8
Marbled Murrelet											1		1
Northwest Crow									30				30
Pacific Loon	1			2	2						1		6
Pigeon Guillemot		12	15	3							1		31
Pintail												30	30
Red-Necked Grebe											4		4
Scaup											3		3
Surf Scoter											10		10
White-Winged Scoter			5		11					2	11		29
Total Birds													260
Harbor Seal					4		1	1	14		1		

Table 5. Bird survey data by point-count station, 24 April 2002.

Species	*Point-Count Station*												
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	*Total*
Bald Eagle	1	1				2							4
Black Oystercatcher			6										6
Black Scoter			9	13	21	8		1					52
Common Raven			2			1			1				4
Double-Crested Cormorant			1										1
Glaucous-Winged Gull			4	4			2		7				17
Harlequin Duck	2	4	4	3	4		5	10			8		40
Mallard									2				2
Mew Gull		1											1
Pacific Loon			1		1								2
Pelagic Cormorant	1	1				2							4
Pigeon Guillemot											1		1
Scaup													0
Surf Scoter											6		6
White-Winged Scoter				2		1					22		25
Total Birds													165
Harbor Seal									28				

Table 6. Bird survey data by point-count station, 25 April 2002.

Species	*Point-Count Station*												
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	*Total*
Bald Eagle	1	2	1										4
Black Oystercatcher	2												2
Black Scoter	3				44		75	45	10		3		180
Brant*			1000	45		100							1145
Bufflehead												2	2
Common Merganser											9		9
Common Raven			2										2
Glaucous-Winged Gull					3								3
Golden Eagle					2								2
Harlequin Duck	5	8	7	14	15	2	4	11	4	6	6		82
Kittlitz's Murrelet							2						2
Marbled Murrelet					1			2					3
Northwest Crow	2									30			32
Pacific Loon	2	1			3				6				12
Pelagic Cormorant					2		1	2			2		7
Pigeon Guillemot			2								1		3
Red-Necked Grebe	1												1
White-Winged Scoter									8				8
Total Birds													1499
Harbor Seal									4	8			

* All brant seen were flying. Three tundra swans were seen on Twin Lake.

Table 7. Bird survey data by point-count station, 26 April 2002.

Species	*Point-Count Station*												
	5	*6*	*6.5*	*7*	*8*	*8.5*	*9*	*10*	*11*	*12*	*13*	*Lagoon*	*Total*
Bald Eagle		1								1			2
Black Oystercatcher						20							20
Black Scoter			12	21	17	12	6						68
Brant								45					45
Bufflehead												12	12
Common Merganser											3		3
Common Raven				1									1
Godwit												1	1
Harlequin Duck	1	3	7	4	16	4	7			9	6		57
Lesser Yellow Legs												1	1
Mallard											12	2	14
Northwest Crow										30			30
Pacific Loon	1					2		2					5
Pelagic Cormorant			2			2	2	1	25				32
Pigeon Guillemot		4	12	1									17
Red-Necked Grebe				1							1		2
White-Winged Scoter					10	12	10				25		57
Total Birds													367
Harbor Seal										50			

Appendix C

QRLV-2 Macroinvertebrate Data

Table 1. Stream 2 macroinvertebrate taxa list.

Taxa	*Oct 98*	*Nov 98*	*Oct 99*	*Mar 01*	*Sep 01*	*Nov 01*	*May 02*
Ephemeroptera							
Baetidae	1		4				
Baetis				68		3	75
Ephemerellidae							
Ephemerella	81	38	73	69	88	62	8
Drunella		4	2		3	2	
Heptageniidae		2	8			1	7
Epeorus					2	1	1
Cinygmula		1		5			17
Plecoptera							
Nemouridae							
Zapada	5	7	11	5	4		4
Chloroperlidae			9	12		17	
Plumiperla	16	36	2		4	25	56
Sweltza			1				
Perlodidae							
Isoperla	8	8	28	19	4	14	1
Capniidae							
Capnia	5	29	1	9		6	
Trichoptera							
Brachycentridae							
Brachycentrus						1	
Rhyacophilidae							
Rhyacophila		2	1		3	2	1
Glossosomatidae							
Glossosoma	27	16	1	6	122	29	16
Limnephilidae		4	36		1		
Ecclisomyia	7	1	3			2	
Onocosmoecus	23	12	6	4			1
Uenoidae							
Neophylax	1						
Coleoptera							
Staphilinidae							
Psephidonus			1				
Diptera							
Chironomidae	30	30	17	54	36	13	76
Ceratopogonidae							
Probezzia	2		1		2	4	9
Empididae							
Chelifera						3	1
Simuliidae	1	1	1	5	1	6	
Tipulidae							
Dicranota	4	2	5	3	8	10	1
Hesperoconopa	3	3		2			1
Hexatoma							1
Molophilus	1		2				
Rhabdomastix						3	
Tipula							
Hemiptera							
Corixidae							
Corisella			1				
Oligochaeta	35	15	5	3	3	7	3
Turbellaria			1	1			2
Physidae							
Physa				1			
Ostracoda	1	6	1				
Hydracarina	1	1	13			2	34
Collembola			1				